Long SETs in op amps

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Outline

- What are “long” pulses?
- Where have they been observed?
- What are their characteristics?
- What are the issues for systems?
- What is the probability of their occurrence?

What are “long” pulses?

- “Long” SETs are output transients that last more than a few 10’s of μs
- The longest are over 1 ms in duration
- In one case the length is indefinite indicating a type of “latch”

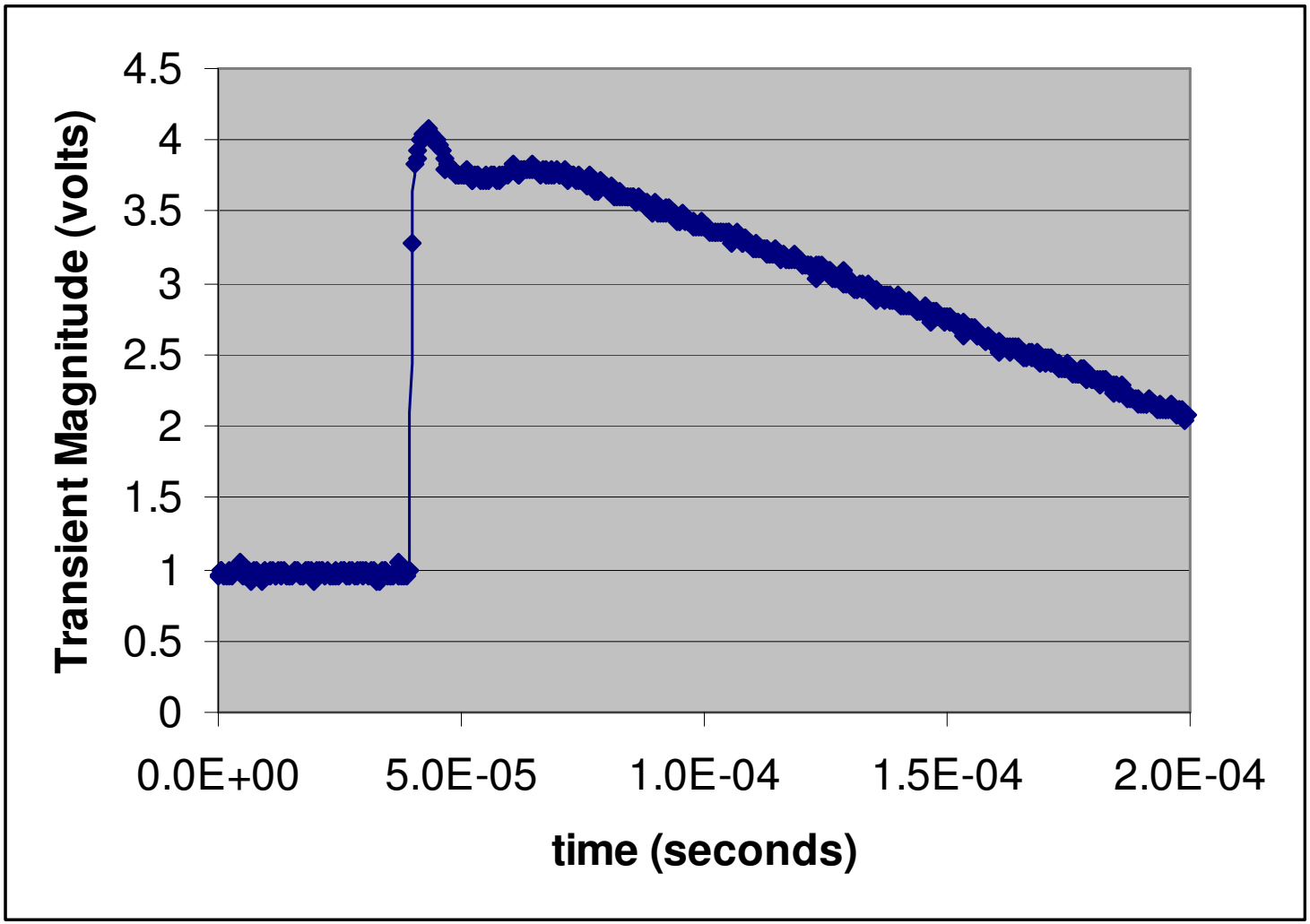
In what circuit types have they been observed?

- LM111- Observed by Crane at TAM (not seen in laser test)
  - Appeared to be random
  - Found out to be a facility problem and not a circuit response
- OP293- Reported by GSFC in tech memo dated Oct 7, 2002 in TAM test (verified by laser)
  - Date code 0021
  - Precision, micropower op amp
  - BiCMOS technology
- LM6144- Observed by Crane at TAM (verified by laser)
  - 17 MHz rail-to-rail I/O op amp
  - Appears to “latch”

OP293

- Tests at TAM with Ar (8.5 MeV-cm^2/mg), Cu (20), and Ag (42.8)
- SETs > 200 μs
  - For LET 16 MeV-cm^2/mg, >200 μs
  - For LET 10 MeV-cm^2/mg, >150 μs
  - For LET 8.5 MeV-cm^2/mg, >100 μs
- SETs of 600 μs observed with laser
- No latchup at LET of 85.7 and 10^7 ions/cm^2

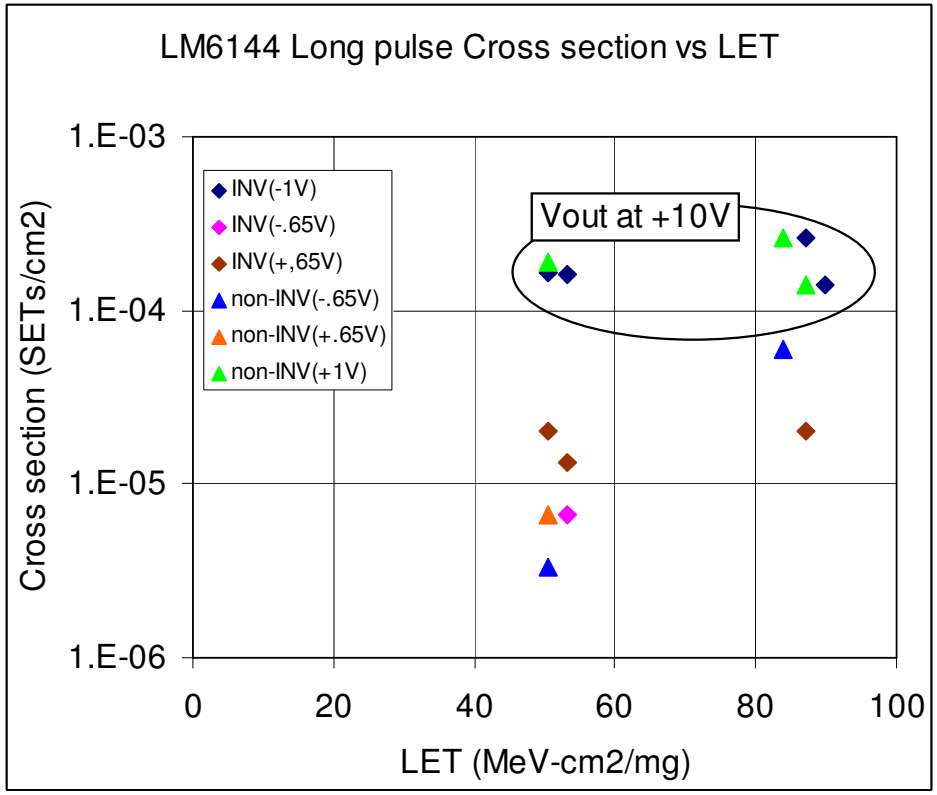
OP293 long pulse

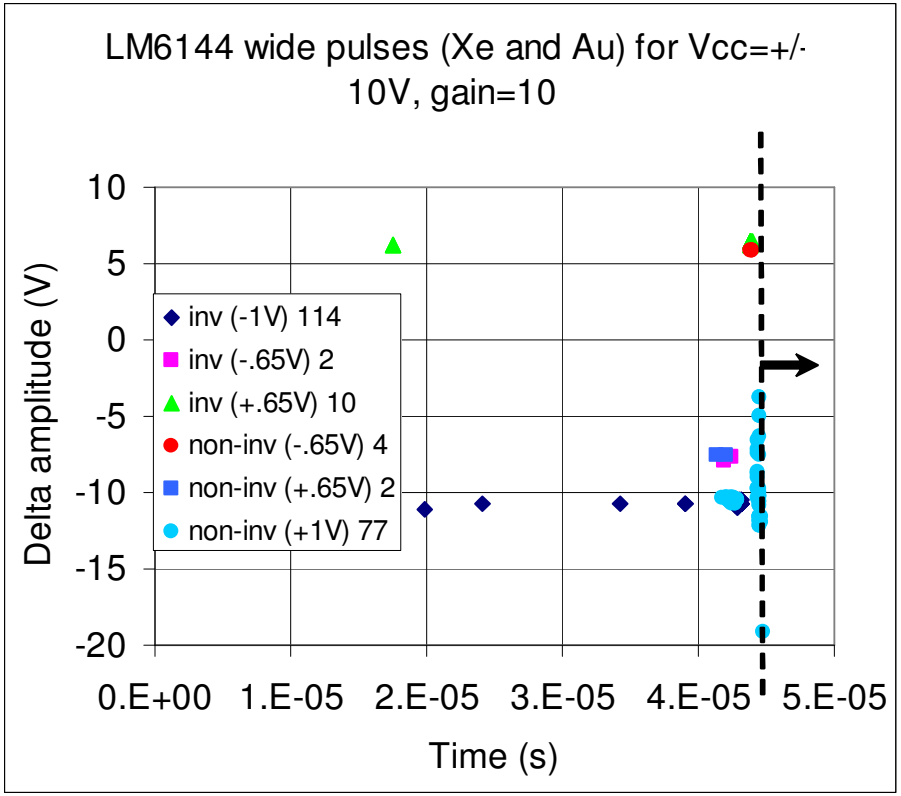


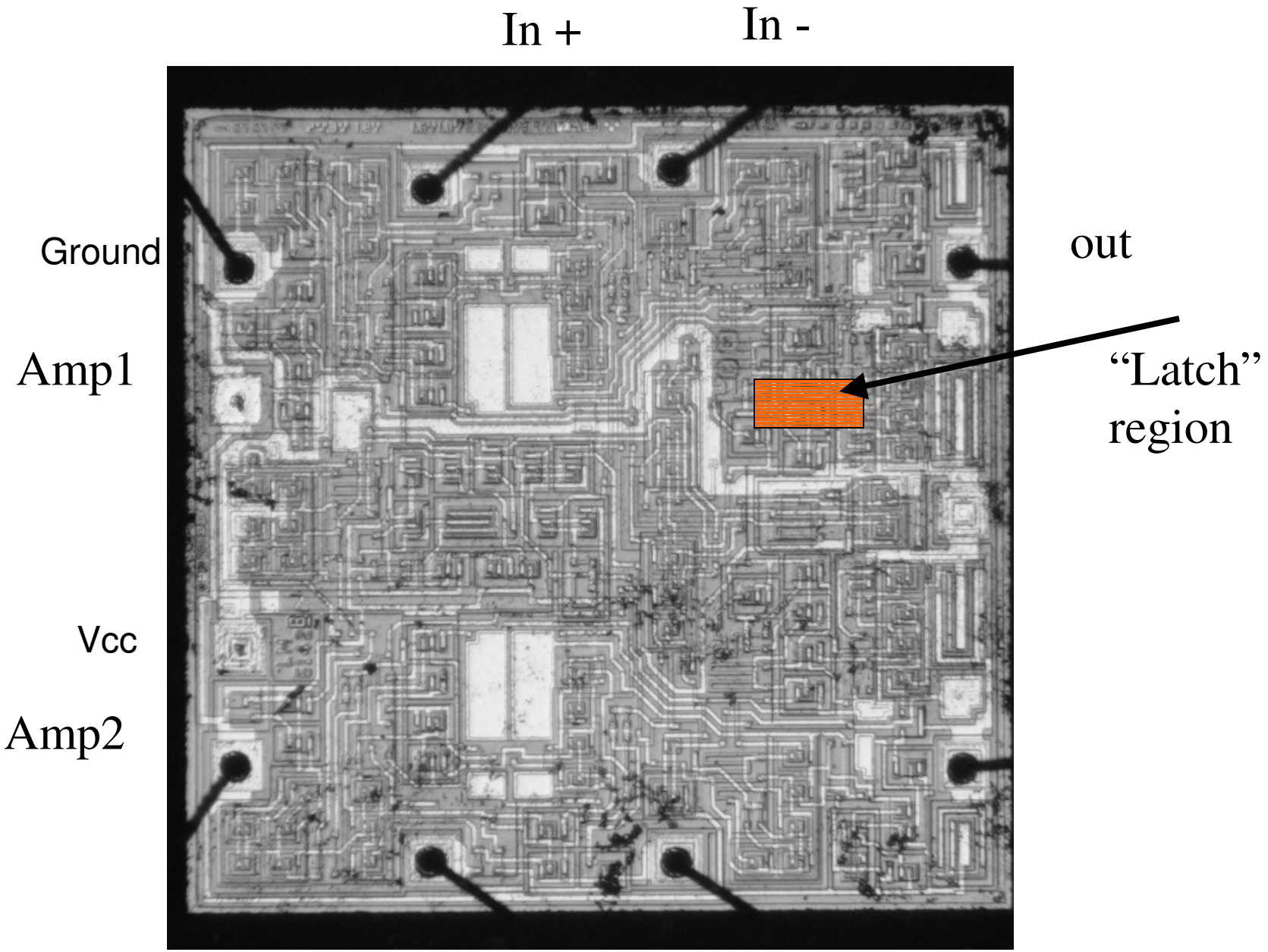
LM6144

- Long pulses observed in two separate tests at TAM, Nov 2002 and March 2003
- Scope set for max of 50 us for most tests, many pulses exceeded this pulse width
- Part tested at Vcc=+/-10V, inverting and non-inverting gain of 10 with Vin=-1V to +1V in 2ed TAM test
- Largest cross section observed for Vout at +10V
- Laser test at 800 nm verified long pulses and determined that for small region of chip the part showed a “latch” with output going to -1V

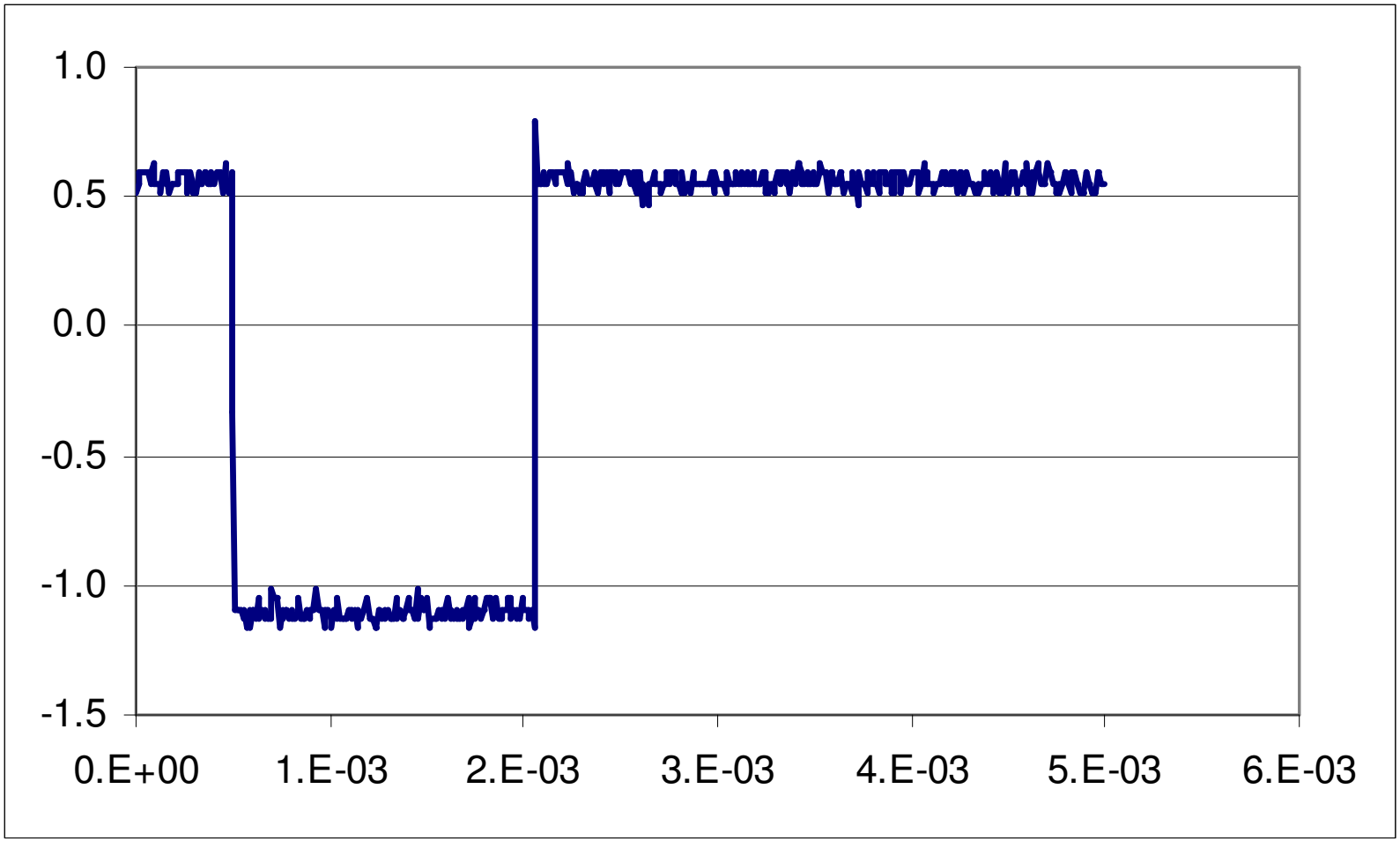
LM6144 long pulse response






In +
In -
Ground
out
Amp1
"Latch"
region
Vcc
Amp2

Example of long SET in LM6144



What are the issues for systems?

- The ASET hardness assurance methodology proposed by Marec, et al at the 2001 RADECS had as a first step the assumption that for op amps and comparators no SET is > 20 μs
- This assumption allowed over 80% of all applications to be dismissed even for a rail-to-rail transient
- Long SETs would significantly increase the required characterization and analysis for systems

What is the probability of occurrence for long SETs?

- OP293
  - Long SETs (>50 us) are common and occur for LETs below 10 MeV-cm^2/mg
  - The threshold LET and cross section for long SETs have not been quantified but probability of occurrence would be significant
- LM6144
  - The device cross section is ~2-3 X 10^{-4} cm^2 for the worst case test condition
  - The threshold LET is high, > 40 MeV-cm^2/mg
  - Hence the probability of occurrence is low